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Changes in Teachers' Behaviour in Secondary Science Education: Implementing a Standards-Referenced National Curriculum

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There is substantial attention worldwide to the quality of secondary school teaching in STEM in Education. This paper reports on the use of Outcome Mapping (OM) as an approach to guide and monitor change in teacher practice and a visual tool, shaped as a Star, to benchmark and monitor this behaviour. OM and the visual tool were employed to guide and document three secondary teachers' behaviour as they planned, implemented and assessed a science unit in the new Australian standards-referenced curriculum. Five key outcome markers in the teachers' behaviour were identified together with progress markers — cumulative qualitative indicators — leading to these outcomes. The use of a Star to benchmark and track teachers' behaviours was particularly useful because it showed teacher behaviour on multiple dimensions simultaneously at various points in time. It also highlighted priorities in need of further attention and provided a pathway to achievement. Hence, OM and the Star representation provide both theoretical and pragmatic approaches to enhancing quality in STEM teaching.

Keywords: *science teacher, secondary education, professional learning, teacher change*

Goals and Objectives

Worldwide there is ongoing attention on the importance of fostering capability in the STEM disciplines (e.g., Chubb, 2012; Rocard, 2007). In Australia, this agenda is set against the introduction of a *standards-referenced* national curriculum (Australian Curriculum Assessment and Reporting Authority, 2013), which involves established standards of achievement and an expectation that all students should have opportunities to reach this standard. Such a curriculum requires an epistemological shift in thinking about curriculum, pedagogy and assessment (Willis, Adie, & Klenowski, 2013). Hence, Australian teachers in the sciences are experiencing substantial pressure to change their practices to align with the underlying philosophy of the new curriculum. The goals of this paper is to report on the implementation of Outcome Mapping (Earl, Carden, & Smutylo, 2001) as an approach to stimulate change in Science teachers' practices and establish the effectiveness of a Star representation (Huitt, 2005) for benchmarking practice and documenting change in teacher behaviour. The two objectives were:

1. *To identify the key outcome challenges and progress markers in a standards-referenced national curriculum?*
2. *To establish how teachers' behaviours change after involvement in this project?*

Theoretical Framework: Outcome Mapping

Outcome Mapping (OM) (Earl et al., 2001) is an approach that can be used to both guide and monitor change. It is appropriate for monitoring the implementation of a new curriculum because it is (1) a participatory method for planning, monitoring and evaluation; (2) focused on changes in behaviour of project participants; and (3) oriented towards social and organisational learning. OM has three stages. *Intentional design* involves aligning program activities with the changes it intends to bring about and purposefully selecting activities to maximise program effectiveness (Steps 1-7). *Outcome performance and monitoring* is developing frameworks to monitor: progress towards the achievement of outcomes; the program's strategies to support outcomes; and the organizational practices used (Steps 8-11). *Evaluation planning* is the final stage where outcome mapping provides a method to identify evaluation proiorities and develop an evaluation plan (Step 12). Due to space limitations, here we report only on *Outcome Challenges* and *Progress Markers* from Stage 1 and *Monitoring Priorities* from Stage 2. *Outcome Challenges* describe how behaviour, relationships, activities and actions will change if the program is successful. *Monitoring Priorities* involves establishing participants' behaviours at the commencement and conclusion of a program directed at change.

Methodology

This study was part of a larger study that employed Outcome Mapping and focused on teacher practice in secondary science education within a standards-referenced national curriculum from two secondary schools

in the Ashes (pseudonym) school sector in a large city. Due to the novelty of the *standards-referenced* national curriculum for teachers, the sector support staff and us, a collaborative project was planned supporting teacher behaviour that aligned with the implementation of the new curriculum. Here we report on the extent to which the capacity of three Year 8 teachers was built as they engaged with the new curriculum. During the project period, these teachers planned, implemented and assessed a Year 8 science unit on War Machines illustrating core concepts in energy and transfer. The culminating assessment task was an individual written scientific report on the group creation and testing of a trebuchet. The teachers' engagement included project briefing and debriefing sessions and a professional learning day focussed on standards-referenced curriculum. They also received ongoing support in the form of site visits and email communication from the researchers and the Ashes' curriculum officers. Communication amongst the teachers in the two schools was facilitated by a project wiki incorporating a document portal and blog with contributions from the teachers, the curriculum officers and the researchers.

The data collection involved video- or audio-tapes of group meetings, individual interviews, modertaion sessions, and a professional learning day. This day focussed on alignment within the curriculum and backward mapping from assessment to instruction, quality assessment tasks, the location of key curriculum and assessment resources, the role of critical evidence in a criteria sheet, and moderation processes. The data also included teachers' written reflections and contributions to the wiki, curriculum documents produced by teachers, and researcher field notes of school visits and discussion with the curriculum officers. These data were assembled into a database. Salient data were sourced from the database to investigate each objective. In addition to text, these data will be presented in a star diagram based on an adaptation of Huitt's (2005) "Brilliant Star" concept. The points of the Stars represent the *outcome challenges* and associated foci. Gradations indicating the extent of each of these Outcome Challenges commence at the centre point and move outward on each arm. These gradations represent *Progress Markers* on the path towards the achievement of each Outcome Challenge. The Star diagram is particularly useful because it can "identify and report change as it occurs simultaneously in multiple domains" (Huitt, 2005, p. 5). By overlaying data from two time periods, the Star can be used to compare teacher behaviours within each Outcome Challenge.

Results and Discussion

The five Outcome Challenges, their foci and associated Progress Markers follow (Objective 1) together with the change in teacher behaviour over the project's life (Objective 2).

Outcome 1- Instruction and assessment are planned collaboratively: Planning [a Foci] as a critical aspect of practice is being considered in terms of collaborative action. The progress markers begin with individual planning [1, least preferred progress marker] where each teacher plans their own learning activities and assessment, and there is little, if any, sharing amongst teachers. Next is team planning [2, intermediary progress marker] where a teacher is assigned responsibility for a unit and other staff contribute. However, there is little shared ownership of the design of the learning activities, the assessment, and the standards as indicators of a quality response. The final marker is collaborative planning [3, most preferred progress marker] where teachers work together to develop a shared understanding of the evidence that would denote achievement of a particular standard of work. While one teacher may be assigned responsibility for this unit, the teachers engage in discussions about the assessment, learning activities and required curriculum standards before teaching commences and continue these discussions throughout the term. At the commencement of the program, Everglade teachers including the Head of Department described their working relationship as involving constant and often informal sharing of teaching practices: "We always share if we do something extra [in teaching practices], we email each other" [2[1]] [Professional Learning [PL] Day]. At the conclusion, there was constant reference to "we" when the teachers reflected on their unit and evidence of a collaborative approach to future planning. Collaboration is the highest progress marker [3]: "One thing we identified, for the evaluating, we always like them to reflect on what happened, what went wrong, how they could improve, but then also a future experiment" [3] [Interschool moderation].

Outcome 2 - Teachers plan by backward mapping from assessment to ensure alignment with curriculum and instruction: Alignment and backward mapping are a part of the planning process and involve teachers planning learning activities that will support student success based on the specified curriculum standards, and critical evidence that would demonstrate achievement of these standards through assessment. The progress

[1] This number indicates the level of progress marker on the Star with 0 as the lowest and 3 as the highest.

markers begin with limited alignment between the assessment and the learning activities [1]. The next progress marker is characterised by teachers having a general idea of the assessment that informs their teaching but the assessment is not written until towards the end of the unit [2]. The final marker is when assessment informs instruction [3]. At the commencement of our project, the three teachers appeared to have a general idea that assessment should inform learning consideration of curriculum in designing assessment and instruction [2]: "We map out the entire year … what content descriptors we would like to target within each unit…then we look at the different contexts we can use to develop those ideas and skills" [2] [PL Day]. However, at the conclusion, there was a greater understanding that assessment should inform instruction [3]: "(Had] they followed those [prac] reports (in their assessment) and everything was there. And as we did it as a class we would talk about [the scaffolding of the assessment]" [3] [Intraschool moderation].

Outcome 3 - Assessment will provide opportunities for all students to demonstrate learning: Assessment task design involves providing opportunities for all students to demonstrate their learning within the identified achievement standards. While all assessments should be valid, clear and fair for all students, this marker specifically focuses on demonstration of learning for all students. The first marker indicates that limited opportunities have been provided for students to demonstrate their learning within the Australian Curriculum as only limited links have been made to achievement standards [1]. Next, the assessment is linked to the standard, but predominately at the 'at level' standard [2]. Students in such cases are not provided with opportunities to demonstrate their understanding at higher levels of thinking and performance. The final marker is when the assessment has been designed to incorporate opportunities for all students to demonstrate their learning. Such assessment incorporates questions where students can respond at different levels of thinking and skills to demonstrate 'above', 'at' or 'below' level achievement standards [3]. At the commencement, the teachers demonstrated a limited link to the standards [1] in their assessment: "When we looked at the standards from ACARA (Australian Curriculum and Reporting Authority), I think we realised that we were probably being a bit too hard on the kids in some areas, and our descriptors didn't necessarily match the ACARA descriptors" [1] [Intraschool moderation interview]. At the conclusion, the teachers had a greater awareness of the need to align their criteria sheet with the curriculum descriptors, however their focus was mostly on the "at level" standard [2]. In discussing their criteria, the teachers focused on what was required in the mid-range on a 5 point scale excluding what would be expected of students who were well above standard (A) or well below standard (E): "So what we've done for the energy transfer and transformation, which is from the achievement standard, is basically what we've graded them at. So that's why it's (a student work sample]) a C-" [2] [Interschool moderation]

Outcome 4 - The criteria sheet supports judgements of the quality of student learning on a specific assessment item: The criteria sheet needs to clearly identify the valued features of the assessment, as well as the different levels of performance of knowledge or skill. A well written criteria sheet will support teachers to make fair and equitable judgements of student learning. The first marker identifies criteria and standards descriptors that are quite vague such that multiple interpretations could be made [1]. Next, is almost the reverse issue where, in trying to be very specific, the criteria and standards descriptors become so detailed or 'atomised' that the integrated or holistic nature of the task is lost [2]. The final marker is achieved when criteria are specific and clear in identifying the critical evidence necessary at each level (A to E). At the commencement, teachers demonstrated an atomised understanding of the criteria sheet [2] which incorporated a criterion for each question. [PL Day notes]. Throughout the program, the teachers continued to grapple with the development of an appropriate criteria sheet that would assist in marking: "Some parts (of the criteria) need to be changed for next year… some areas could be less specific (Atomised) and other areas could be more specific to make it easier" [Intraschool moderation]. After the teachers realised that there was considerable difference in how they had marked using the criteria sheet they decided that remarking was necessary: "We have marked this completely differently … We will have to go back and re-mark" [2] [Intraschool moderation].

Outcome 5 - Ongoing professional dialogue about learning and assessment occurs at school and system levels: Professional dialogue about learning and assessment is integral to effective planning and assessment within standards-referenced assessment systems. Teachers need to have time to discuss standards so that common understandings can be developed. The first marker indicates professional conversations that are focussed on peripheral issues of quality teaching [1] (e.g., timetabling exams or neatness of students' assessment). These may be important for specific reasons but are not critical indicators of learning. Next is a focus on either content or the learners where teachers may discuss the content of their lessons or how best to

support particular learners but they do not consider the content and learners as interrelated [2]. Ultimately, professional conversations should focus on how to support student learning through effective teaching practices that make learning visible to students [3]. At commencement, the teachers' focus was on content or learners [2]: "What skills the kids don't have …" rather than what knowledge the students had that could be built on [2] [PL Day]. However, by the conclusion of the project, the teachers were considering both the content and the learners: I think it's [the moderation discussion] valuable in terms of also knowing maybe where they didn't do so well (and) how we can give them the help that maybe they need to get up to that next level" [3] [Intraschool moderation].

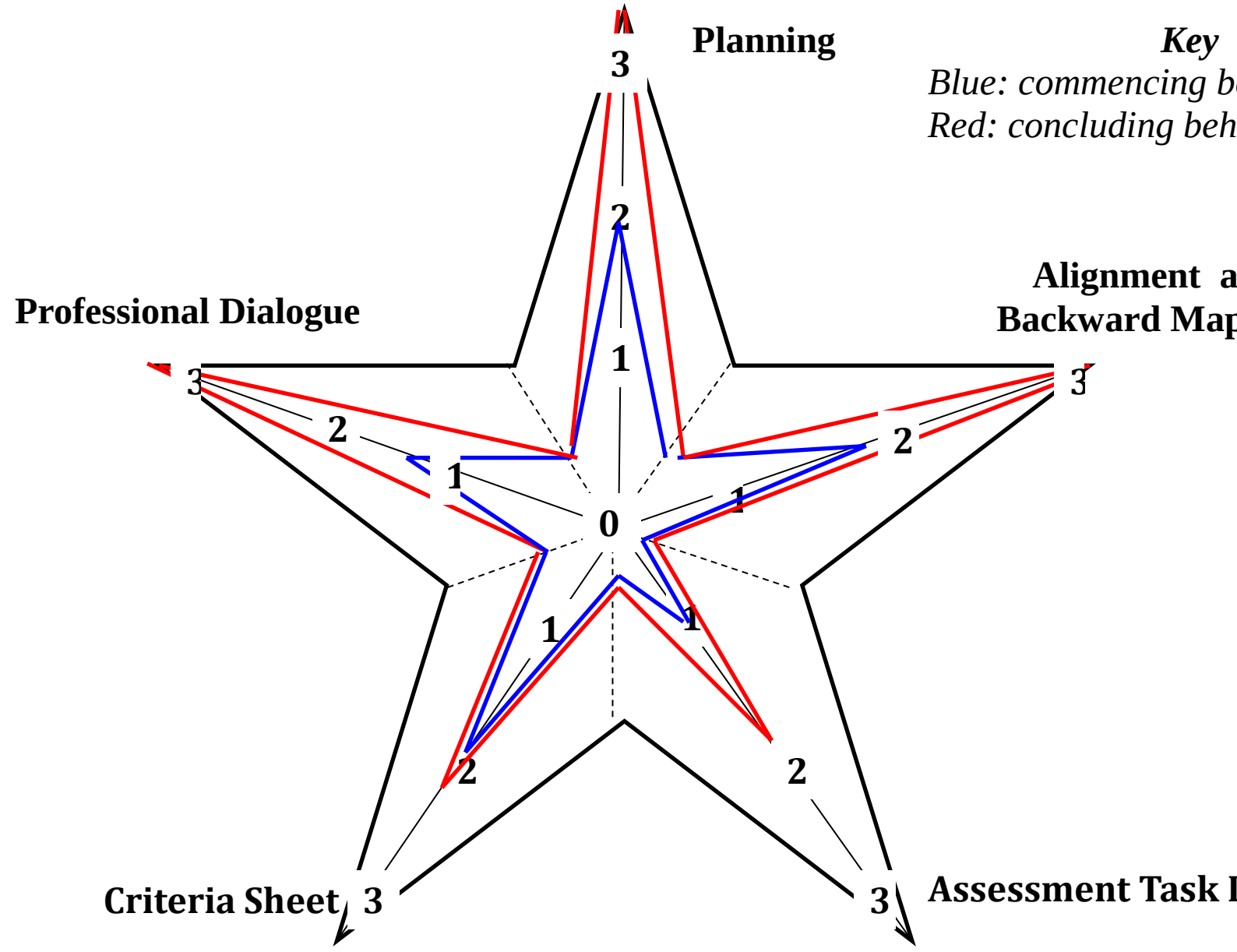

Figure 1. Everglade College: Commencement and Conclusion

In order to benchmark where the teachers commenced on each of the five outcomes, their progress and future priorities we have used a Star diagram (Figure 1). Notably, between the commencement and conclusion of the program there were the attainment of the highest progress markers for Planning, Alignment and Backward Mapping, and Professional Dialogue (Objective 2). There was some improvement in Assessment Task Design and the Criteria Sheet, however, these remain priorities for these teachers.

Conclusions and Significance

The identification of the Outcome Challenges and the Progress Markers commenced at the start of the project but was refined throughout the program as we became clearer in what the distinguishing factors of a standards-referenced curriculum were and analysed the teacher behaviour data. The Challenges and Markers served as points of reference for the researchers, teachers and the Ashes' sector officers. The use of Stars to represent teachers' behaviours was particularly useful. The Star provided a pathway to the achievement of Outcomes via the Progress Markers and facilitated representation of teacher behaviour on multiple dimensions simultaneously by showing snapshots of teacher behaviour at different points in time. It also provided a concrete means for teachers and researchers to share and discuss their perceptions of teacher behaviour and to produce a Star representing consensus viewpoint. Finally, it clearly highlighted where there is still room for improvement in teacher behaviour and, hence, priorities for future professional learning to improve the quality of secondary school teaching in the STEM disciplines.

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